Engage, Investigate, and Report

Enhancing the Curriculum with Scientific Inquiry

Sally Blake

Young children are called natural scientists for good reason. Even infants investigate their surroundings, using their senses to look, touch, smell, hear, and taste. Soon, children start asking why or how come. As they discover objects and situations that are puzzling or intriguing—things that provoke their curiosity—they begin looking for ways to find answers, all in an effort to understand the world around them. This is the essence of the science inquiry process.

Children's daily play naturally engages them in science (Klein et al. 2000). For example, as a child plays with water, he splashes, pours, swishes, and adds things to see what will happen; if it's in a puddle, he may jump in! All of these actions are ways of exploring the nature of water. Through these investigations, a child develops explanations about the world and explores scientific concepts. Free exploration and experimentation help develop the inquiry skills and physical senses that serve as a basis for all science learning (Lind 2004).

Supporting children's natural, interactive inquiries is recommended in the National Science Education Standards (NRC 1996) and is identified as best practice by the National Research Council (NRC 2005) and the National Science Foundation (NSF 2000; see www.nsf.gov/cise/kdi/tools/lrng_forum.html).

Science learning: Children's potential

Science inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on evidence gathered from their work. It also refers to the process of developing knowledge and understanding of scientific ideas and of learning how scientists study the natural world (NRC 1996). Inquiry is a process of active exploration and a way of thinking about learning. As scientists tell us, to learn science, one has to do science. Early childhood is a critical period for science education, but only if educators use an approach that reflects young children's unique needs, interests, and abilities (Elkind 1999).

Models of instruction: The research

While most of us were introduced to the scientific method in textbooks and school activities, new research is redefining the approach for better learning. The new guidelines for teaching children the scientific method emphasize helping children develop (1) a familiarity with a discipline's concepts, theories, and models; (2) an understanding of how knowledge is generated and justified; and (3) the ability to use these understandings

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to engage in new inquiry (NRC 1996). To support this approach, the National Research Council recommends that science be taught through inquiry. While NRC's guidelines were written with older children in mind, I believe that age-appropriate applications based on the combination of science standards and early childhood standards work with young children

Early childhood educators have long supported the use of investigations and active explorations for children's learning. Preschool- and primary-level science is and must be a hands-on enterprise. The consensus on this can be clearly seen in documents such as *Science for All Americans* (AAAS 1989), *Benchmarks for Science Literacy* (AAAS 1993), and *National Science Education Standards* (NRC 1996), which align with developmentally appropriate practice (Copple & Bredekamp 2009).

Science is a process of finding out and a system for organizing and reporting discoveries. It is a way of thinking and trying to understand the world (Lind 2004). Bredekamp (2006) suggests that formulating hypotheses, making observations, collecting data, and revisiting hypotheses are processes that should define young children's project work in any area.

Teachers of young children should note that while discovery learning is developmentally appropriate, it will not ensure that children understand the science concepts they explore. Misconceptions from observations may actually harm children's science understanding (NRC 2005). While play and naturalistic investigations are important, it is equally important to discuss children's investigations to help them make sense of their observations and their thinking (Blake 2008).

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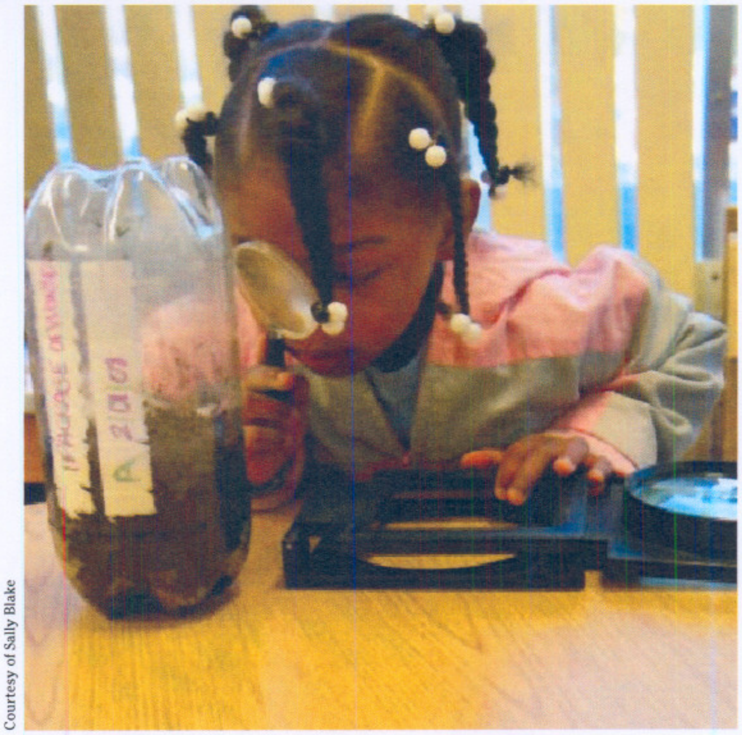
The inquiry cycle

The National Research Council (2005) recommends the use of an inquiry cycle of learning in science teaching to support the inquiry process. This inquiry cycle approach includes five phases that support early childhood investigations. I outline the cycle using the example of an investigation of worms.

Phase 1: Engage children's interest. The children may express a special interest in exploring a topic or the teacher could use an appealing story, poem, demonstration, or discussion to stimulate children's interest. This establishes



Courtesy of Sally Blake

the investigation topic. Educators should not expect children to discover everything for themselves; rather they should focus on relating new science knowledge to previous knowledge and experiences, so children can build a consistent picture of the physical world (Lind 2004).

At the Barbara K. Lipman Early Childhood School and Research Institute, Reggio and Montessori teachers intrigue the 3- and 4-year-old children by pointing out earthworms found in the outdoor classroom. They then work with the children to construct a worm habitat using soil, newspaper, vegetable scraps, and empty plastic two-liter bottles. Interest builds when the teacher reads aloud books like *Wonderful Worms,* by Linda Glaser, or *Diary of a Worm,* by Doreen Cronin. The teacher can discuss the books with the children, then leave them in the classroom library so children can revisit them on their own.

Phase 2: Prepare to investigate. Next, the teacher and children decide on one or two specific questions to investigate. This is also the time to determine how children will carry out their investigation and to assemble the needed tools. The children might want to explore how worms move, how long worms are, how worms feel, whether worms can smell or see, how light affects worms, or why worms live underground. Children can work in pairs or small groups, depending on their individual interests in the investigations.

Help the children narrow their focus to one or two questions, then guide them in identifying the tools and specific sources of information they will need to answer their questions. For a worm investigation, the class might want flashlights, hand lenses, measurement devices, plastic tongs, and a dark area for worm observation. A box lined in black

paper works well for observation. Place the worms on a moist paper towel or near damp soil. Worms need moisture to live and dry out quickly when exposed to heat and light.

The familiar K-W-L chart can be of use in the initial discussions of this phase. Based on discussions with the children, the teacher fills in the three columns of the chart to show "What We Know," "What We Want to Know," and "What We Learned." For inquiry learning, it is particularly helpful to add another column—"How We Will Learn It"—creating a K-W-H-L chart.

Phase 3: Investigate. The teacher organizes classroom areas with the tools and items for investigation, or has the children collect items to investigate from their environment. Children do much more than observe in this phase. They also collect and share information and make inferences from the information.

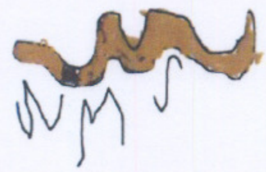
Children can draw what they see when looking at the worms through hand lenses, dictate their observations of worms' movements, take photographs, and complete simple graphs showing data like the lengths of different worms. It is important to save all the collected data for use in the last two phases of the inquiry cycle. As the children are observing, encourage their data collection through open-ended questions and model the different ways to record the information. Ask questions such as, How can we compare worm behavior in dark and light conditions? How do worms react to touch? How do worms move?

Phase 4: Prepare to report. Until the children have practice with the inquiry process, they will need guidance during this phase. Initially, teachers can discuss what the children learned during the investigation and help them organize and prepare their data to present to other children and adults.

The class can document their investigations, for example, by making tally marks to represent how many worms they are observing, draw the worms, and report how long the worms are (younger children might say things like "shorter than a pencil" or "about the same length as a crayon"). Comparison is important in developing scientific inquiry thinking. An example of information prepared for reporting might look the data collected in "Evidence Gathered in Worm Investigations" (p. 52).

Phase 5: Report. The class now comes back as a whole or in smaller groups to report and discuss the findings and to decide what the findings mean based on observations and data. Each group shares their data and talks about what they think they have learned. The teacher guides thinking through questions like, "How did you determine

Evidence Gathered in Worm Investigations

How many worms?	How long?	Difference in light and dark?	How do worms feel?	Can worms smell?	Worm drawing
|||| 4	"Longer than my finger."	"Worms squiggle and shrink when you put them in the light."	"Worms feel wet and mushy."	"Yes, they don't like smelly things."	

_____?" and "Why do you think _____?" and helps the children learn to question the findings themselves.

Teachers of younger children can keep a whole-group science journal for recording and reporting science inquiry investigations. They can use the journal for group discussion, presentations to families or other classes and teachers, and as an information source to develop further investigations. The journal can include child-dictated descriptions of explorations and the results, children's drawings of data, or photos of their work. The journal will include all the data collected, and children can dictate their conclusions. This journal should be used for all science inquiry—formal (like with the worm investigation) and naturalistic (an individual child's interest in leaves from home). An entry in the group science journal might look like the dictated comments in "Science Journal Entry Based on Class Discussion." As the school year progresses, children will gain the skills needed to maintain their own science journals.

The last part of the final phase is talking about what else the children might want to know about their investigation topic. As the class explores further, it is important to keep whole-group and individual journals up to date, adding new information and correcting misinformation.

> **Young children's sense of wonder is a natural asset that can be refined in preparation for life-long inquiry skills.**

Science Journal Entry Based on Class Discussion

What we learned about worms from our investigation	What we think this means
Worms don't like light. Worms like dark.	"This is why worms live in the ground."
Worms wiggle. Worms feel mushy.	"Worms don't have bones."

Tips for Organizing Investigations

What we want to study

- Identify a broad theme

What information do we need?

- Discuss what we want to learn about the theme

How will we get the information?

- Make observations
- Conduct interviews
- Execute simple procedures (for example, follow the recipe)
- Collect and record data

How will we communicate the information?

- Organize and display data (pictures, charts, tables, graphs, journals, books, and so on)
- Explain concepts (relationships, examples/nonexamples)
- Present information (explain or summarize the concept or results)
- Extend presentation of information (relate ideas to the real world, between content areas, or from multiple sources)
- Generate questions from observations, make predictions

How will we analyze the information?

- Draw conclusions using data
- Apply and adapt information to real-world situations

Conclusion

© Subjects & Predicates

Concern about science education and science standards has been driven by the science achievement gaps between schools in different communities in the United States and between U.S. students and their international peers (Gonzales et al. 2008). According to trends in National Assessment of Educational Progress (NAEP) scores across a 10-year span, when comparing 4th-grade scores to 12th-grade scores, the longer students stay in the U.S. school system, the worse they do on science assessments (Grigg, Lauko, & Brockway 2006).

Because the data continue to indicate that science learning in the United States has made little or no progress for decades, we need to examine what happens along the continuum of educational experiences that influences science learning. Early childhood educators need to study how children acquire science concepts (Elkind 1999). To become scientifically literate, educators must introduce children to essential experiences of science inquiry and explorations must begin at an early age (Lind 2004).

The science inquiry learning cycle can be a valuable tool for learning and may be instrumental in the development of long-term science literacy. Inquiry supports and validates young children's natural curiosity about the world around them. Young children's sense of wonder is a natural asset that can be refined in preparation for lifelong inquiry skills. The key to science literacy is in early childhood programs. For children to develop to their full potential, we need to make sure we reinforce the process of scientific thinking through science inquiry investigations.

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